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ABSTRACT

Concept mapping, a technique based on David Ausubel's theory of meaningful learning, involves the organization of concepts into an hierarchical arrangement. Suggestions for incorporating this learning strategy into the biology classroom are presented and discussed. Steps in concept mapping include: (1) identifying important concepts in the study materials; (2) ranking concepts from the most general to most specific; and (3) arranging concepts on a piece of paper and defining connections between related concepts. A concept map for animals is developed from a textbook paragraph. Three student-designed maps (dealing with photosynthesis, cells, and organic compounds) and a form for quick scoring are included in an appendix. Also included are forms for assessing student-developed concept maps and a list of definitions for the word "concept." (DH)

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USING CONCEPT MAPPING IN THE BIOLOGY CLASSROOM *

Workshop presented at:

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*- Please note that much of this paper has been adapted from a paper titled " Concept Mapping and Gowin's Vee: Successful Learning Constructs for the Science Classroom" presented by J. B. Kahle, J. D. Lehman, and C. Carter at the NSTA National Convention, April 9, 1983.

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Introduction

The importance of meaningful learning of concepts and principles in school learning has been stressed by prominent cognitive psychologists (Ausubel, et al., 1978; Gagne, 1977). According to Ausubel's learning theory, concepts play a central role in the acquisition and use of knowledge. In order to learn meaningfully, students must relate ideas to one another and to existing conceptual schemes. The main thesis is that "umbrella" ideas, typified by concepts and principles (rather than unrelated facts), must be established before information can be meaningfully learned and retained.

Novak (1976; 1980) and Stewart, Van Kirk and Rowell (1979) stress the need for instructional materials which will enhance meaningful learning by focusing on the conceptual organization of knowledge and the learning of concepts. In addition, the work of Novak, et al. at Cornell University indicates that students can be aided through explicit guidance in learning strategies. One learning strategy technique that is particularly useful is concept mapping. Concept mapping aids students in understanding the important role that concepts play in learning and retention.

Work by Novak, et al. (1981) with predominantly white, middle school students, by Kahle, et al. (1983) with minority, high school students, and by Joyce and Well (1979) and Edwards (1982) at Bill Reed Junior High School in Colorado with seventh grade students, indicates that students can understand, can learn to use, and can benefit from the use of concept mapping and concept attainment in the science classroom. Further, science teachers can adopt and routinely incorporate these techniques into their own teaching/learning strategies.

Concept Mapping

Concept mapping is a technique which follows Ausubel's theory of meaningful learning. It involves the development of concepts in a body of instructional material, the organization of the concepts into a hierarchical arrangement, and the formation of explicit relationships between related concepts. The result is a visually efficient, two-dimensional representation of some body of knowledge.

The basic concept mapping technique is relatively simple to learn. To get an idea of how to make a concept map, read the paragraph about animals below.

Animals

> Everyone is familiar with multicellular animals. Animals with backbones are called vertebrates. Some vertebrates, like sharks, robins, snakes, frogs and whales are considered chordates because of their dorsal nerve cord. Earthworms, planaria, sponges, jellyfish, crabs, beetles, squid and starfish, on the other hand, are considered to be invertebrates because they don't have a backbone. Arthropods, the largest group of invertebrates, includes crustaceans (crabs) and insects (beetles). One of the major characteristics that separates the chordates is the skin and its appendages. Fish have fins and scales, amphibians have moist skin, reptiles have dry skin covered with scales, birds have feathers and mammals have hair on their bodies.

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1) The first step in the technique of concept mapping is to identify the important concepts or ideas in the study materials. After all, you have to be able to find the important ideas before you can learn them.

But, you may be wondering, just what is a concept? The definition used herein describes a concept as a regularity in events or objects that has been given a name. More simply put, a concept is an idea. For instance, "dog" is a concept. There are many different kinds of dogs but all dogs have some things in common. That is, all dogs share certain attributes or characteristics. Just about everyone knows what you mean when you say "dog". Dogs have four legs; they have fur; they bark and so on.

Look back at the paragraph about animals. What are the important concepts in the paragraph? What must you know in order to understand the content of the paragraph? One useful way to identify the important concepts is to go through the paragraph and underline the concepts. Alternatively, you could jot the concepts down on a sheet of paper. Go back now and underline the important concepts in the animals paragraph. Then, we will continue with the remaining steps in concept mapping.

So, what did you think were the important ideas in the animals paragraph? There were a number of concepts, such as animals, multicellular, backbone, vertebrate, sharks, snakes, frogs, robins, whales, chordates, dorsal nerve cord, earthworms, planaria, sponges, jellyfish, crabs, beetles, squid, starfish, invertebrates, arthropods, crustaceans, insects, skin, appendages, fish, fins, scales, amphibians, reptiles, feathers, birds, mammals and hair. To understand and learn the information in the paragraph, you must understand these concepts.

*** Remember - the first step in concept mapping is to identify the important concepts.

2) The second step in concept mapping is to decide upon the relative importance of each of the concepts. Look again at the concepts from the animals paragraph. Are all of the concepts equally important? Do some concepts include more than others? Which concepts are the most general? Which concepts are the most specific? In the space below, rank all of the concepts from the animals paragraph in order from the most general to the most specific.

A RANK-ORDERING OF THE CONCEPTS INCLUDED IN THE ANIMAL PARAGRAPH

ANIMALS
MULTICELLULAR
VERTEBRATES
INVERTEBRATES
BACKBONES
NO BACKBONES
DORSAL NERVE CORD
CHORDATES
ARTHROPODS
FINS
SCALES
MOIST SKIN
DRY SKIN
FEATHERS
HAIR
CRUSTACEANS
INSECTS
FISH
AMPHIBIANS
REPTILES
BIRDS
MAMMALS
STARFISH
EARTHWORM
SQUID
PLANARIA
SPONGES
JELLYFISH
CRABS
BEETLES
SHARKS
FROGS
SNAKES
ROBINS
WHALES

What did you decide? Which concept did you think was the most important or most general? The most important concept in the paragraph is certainly animals. That is pretty obvious since most of the paragraph is about animals. Less general but still important concepts would be concepts such as vertebrates, invertebrates, chordates and arthropods. Finally, it is not very difficult to identify the most specific concepts. These would include the examples of vertebrates (sharks, frogs, robins, whales) and the examples of invertebrates (earthworms, planaria, sponges, jellyfish, crabs, beetles, squid, starfish). This represents a rank ordering of the concepts from most general to most specific.

*** Remember - the second step in concept mapping is to rank the concepts from most general to most specific.

3) The third and final step in concept mapping is to put the concepts on a piece of paper (most general to most specific) and make connections between related concepts. To show the connections, lines are drawn between the related concepts and words or statements are written on the lines to indicate the precise nature of the relationships between the concepts. General concepts may be linked to the more specific concepts beneath them on a concept map. In addition, lines may be used to cross-link concepts from one part of a map to another.

To get a better idea of this last important step, turn to the next page. There you will see a sample concept map of the information in the animals paragraph.

Do you see how the concept map clearly shows all of the concepts, their rank order, and their interrelationships? Concept mapping is a visual means of summarizing information. Concept maps can be a valuable study aid.

*** Remember - the third step in concept mapping is to arrange the concepts on a piece of paper, most general to most specific, and to make and define connections between related concepts.

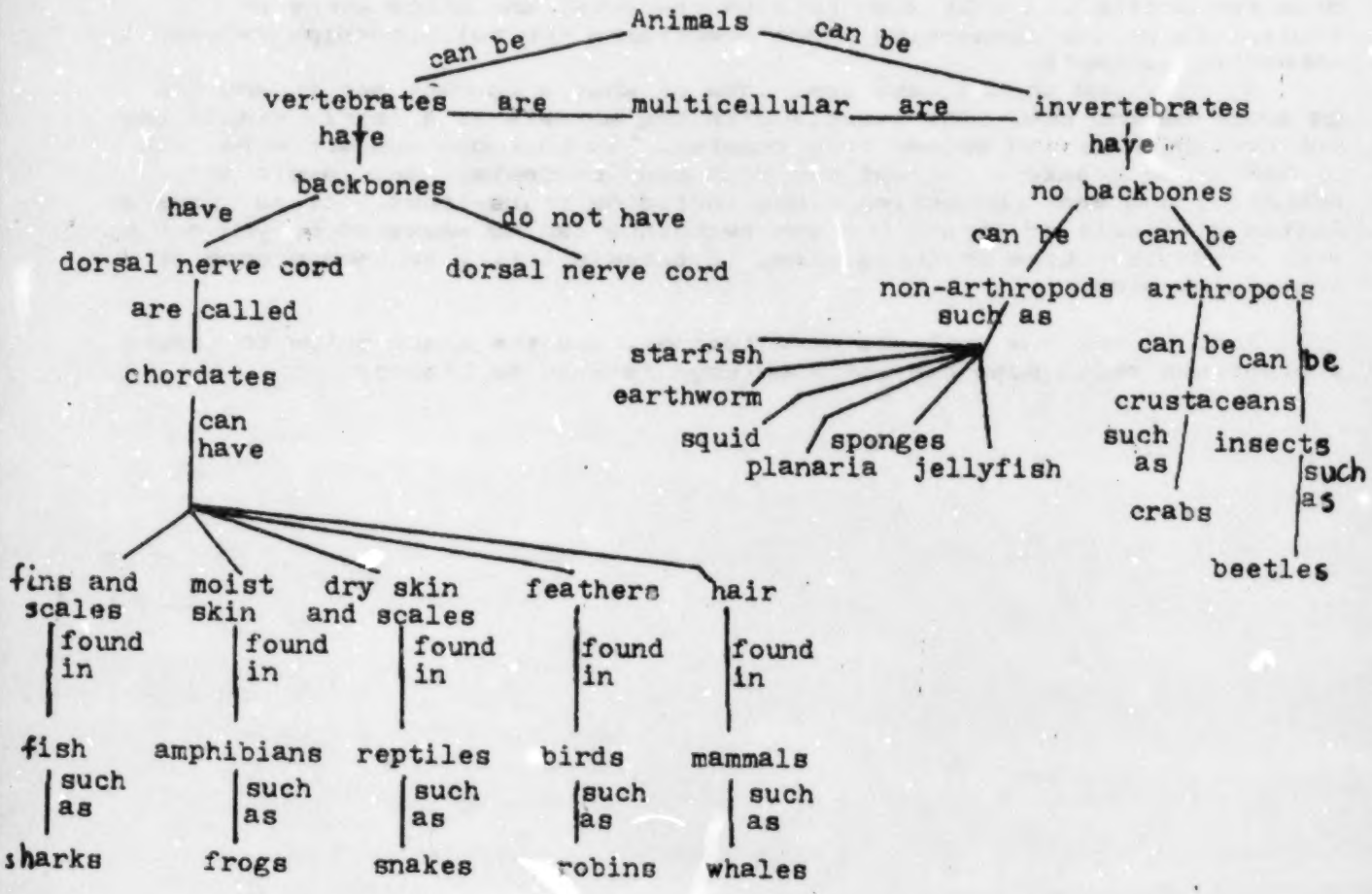
As you can probably tell from the concept map shown, concept maps do not have to be symmetrical. And, there is no perfect or absolutely right way to make a concept map, although some maps may do a better job than others of making the meanings of concepts and their relationships clear. When making a concept map, most students (and teachers) usually need to try a few practice maps before drawing a final one. It may take several tries to come up with a good concept map.

Concept mapping is a shortcut way of illustrating information. All of the information from the animals paragraph is contained in the sample concept map. While it may seem like a lot of work at first, once you get used to concept mapping, you'll find it a very useful, helpful, and efficient way to learn. Concept mapping is an excellent technique for reviewing or studying difficult reading materials or just for illustrating the relationships of various concepts in a body of knowledge.

Just to summarize, the three steps to follow when constructing a concept map are:

1) Identify the important concepts in the study materials. (Note: while you probably will concentrate on scientific concepts, it is acceptable to use non-scientific concepts, like rare and common, to make a map more easily understood).

Concept Map of Animals Paragraph Information



2) Rank order the concepts from most general to most specific.

3) Write the concepts on a piece of paper from general to specific, draw connecting lines between related concepts, and write words or statements on the connecting lines describing the relationships between the connected concepts.

By now, you should have some idea of what a concept map is and how you go about making one. The example with the animals is a fairly simple one, but concept maps can become very complex. In your own subject area, you probably can create a concept map with many concepts, many levels and branches, and many connecting lines including cross-links. It may seem a little difficult at first, but the technique can be mastered by you and by your students. Like anything else, it takes practice to become good at concept mapping.

Just to see how well you have learned, use the space below to create a concept map about some body of knowledge related to biology.

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APPENDIX A

Sample Student-Constructed Concept Maps

CLASS Biology 1:30 TEACHER Mrs. Thornton NAME Grace Johnson

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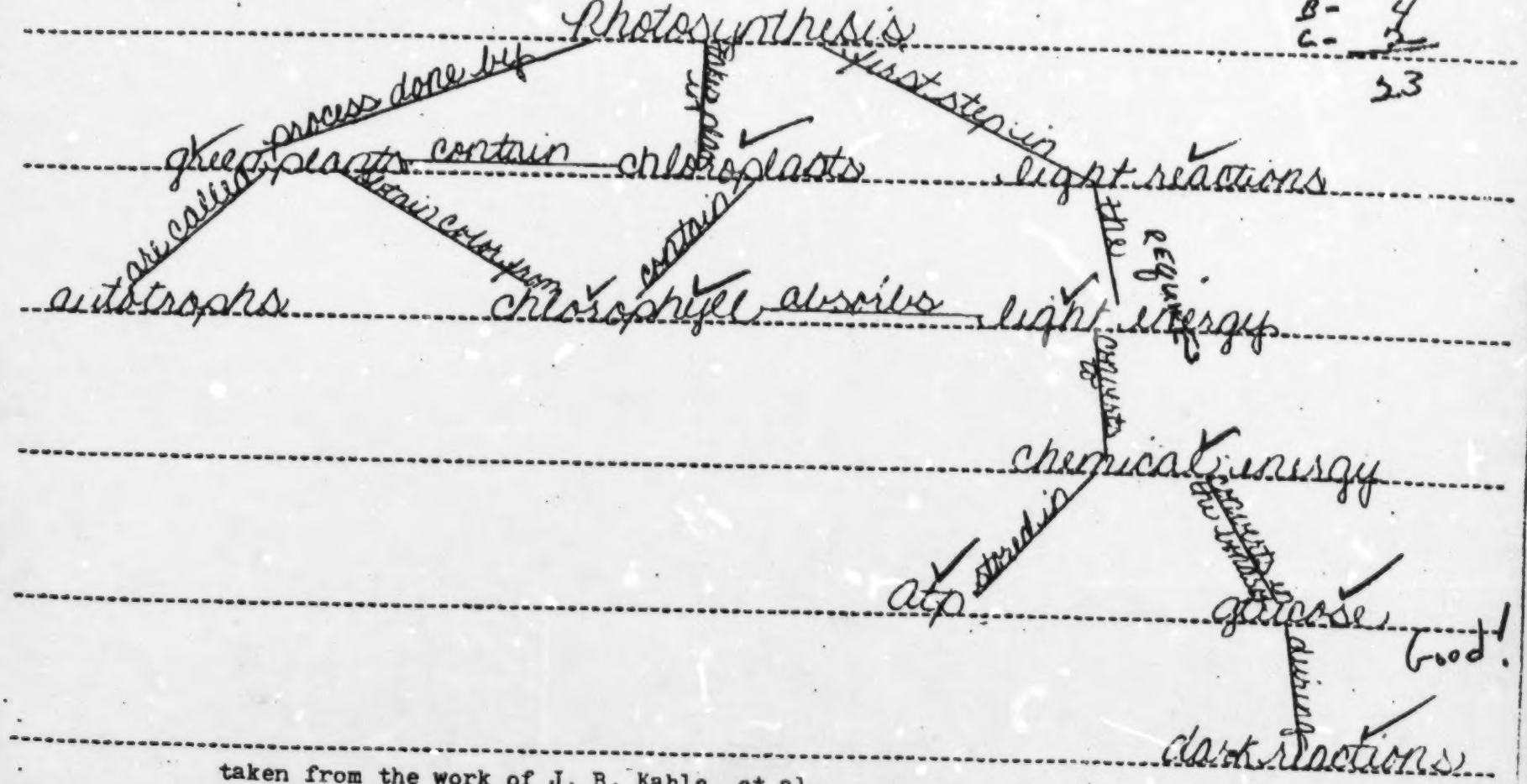
Activity #2
Summary of Photosynthesis

115% 20/20

In the space below, use the study aid that you have learned to make a summary of the information about photosynthesis which you just covered. When you have finished, hand you summary to your teacher.

R- 12
H- 5
B- 4
C- 2
23



taken from the work of J. B. Kahle, et al.

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12

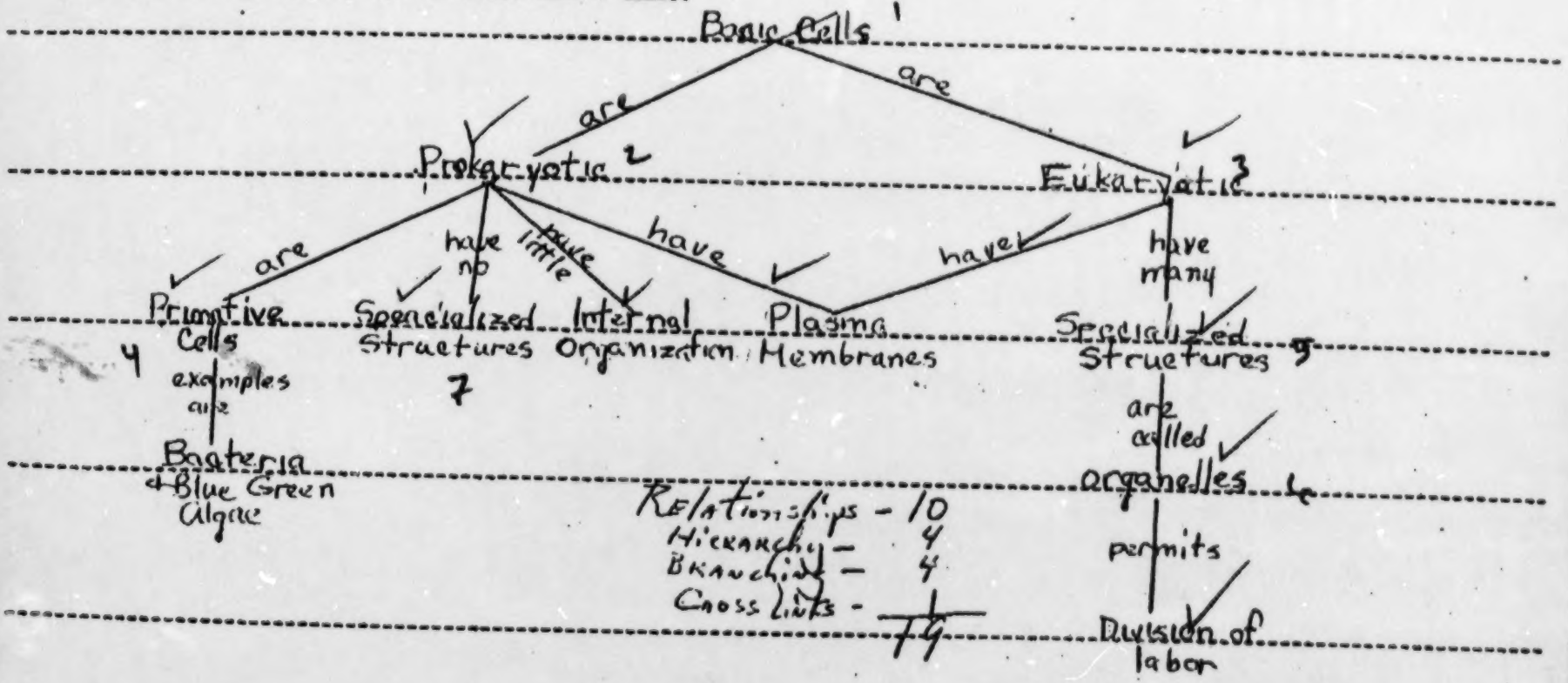
CLASS Biology TEACHER Mrs. Thornton NAME Gregory Davis

10

Activity #2

Summary of Prokaryotic and Eukaryotic Cells

In the space below, use your study aid technique to summarize the information you have learned about prokaryotic and eukaryotic cells. When you have finished, hand it in to your teacher. You need not use all of the space. If you need more space, draw in extra dashed lines.



13

taken from the work of J. B. Kahle, et al.

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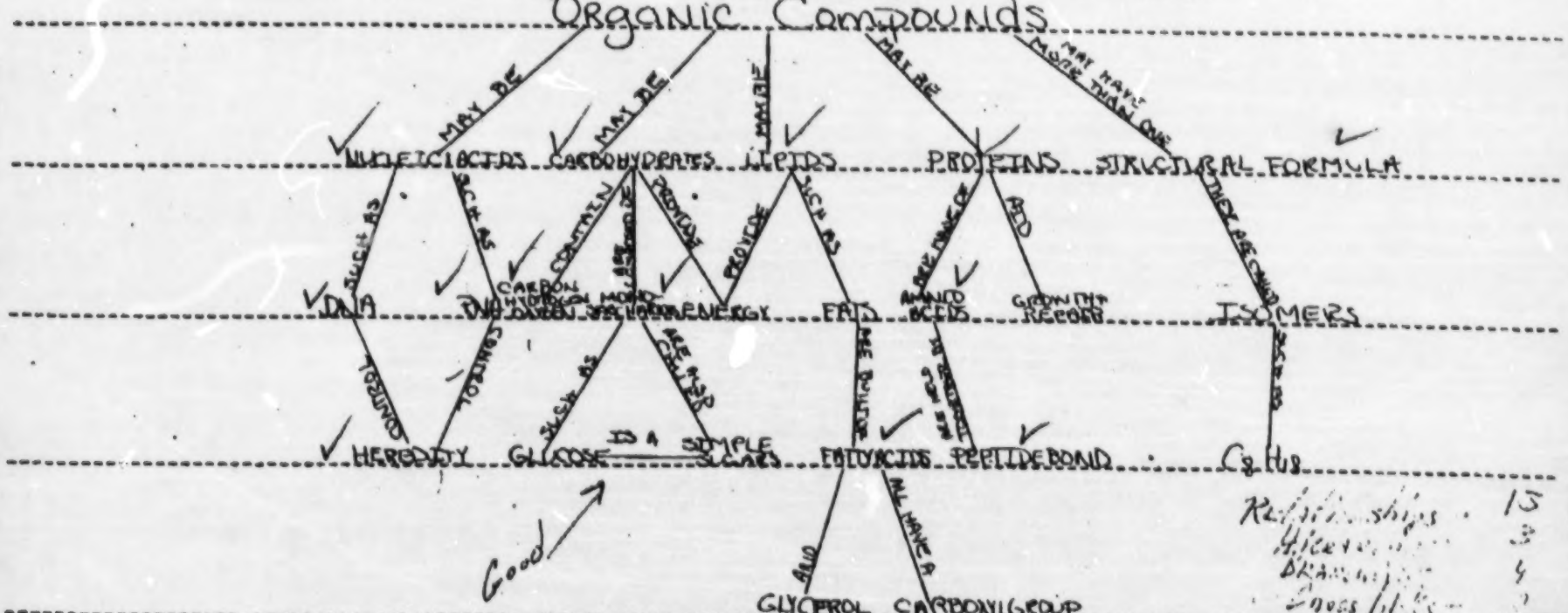
CLASS 1:30 TEACHER MRS. H. THORNTON NAME Carolyn Ewing

Activity #3
Organic Compounds Summary

In the space below, use your study aid to summarize what you have just learned about organic compounds. When you have finished, tear out this sheet, put your name on it, and hand it in to your teacher. You need not use all of the space. If you think that you need more space, you may add extra dashed lines.



Relationships 15 16
Vocabulary 3 3
Drawing 4 4
Essay 2 1
21 24

taken from the work of J. B. Kahle, et al.

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APPENDIX B

Concept Map Evaluation Forms

GENERAL OVERVIEW FOR STUDENT-CONSTRUCTED CONCEPT MAPS (FORM A)

	YES	NO	NEEDS WORK
1. Are relationships between concepts indicated on line and are they content correct, that is valid?	( )	( )	( )
2. Are the concepts arranged from general to specific? (Look for the most inclusive concept at the top; examples at the bottom.)	( )	( )	( )
3. Are the concepts linked? (Look for lines between the concepts. The relationship between concepts should be indicated. That is, something should be written on the lines.)	( )	( )	( )
4. Is the map hierarchical? (Look for more inclusive concepts connected to two or more lower or subordinate concepts.)	( )	( )	( )

Figure 1[illegible] General Overview for Quick Scoring of Student-Constructed Concept Maps.

taken from the work of J.D. Novak

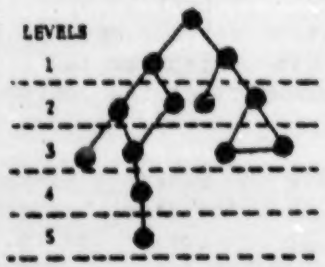
COMPREHENSIVE FORM FOR ASSESSING STUDENT-CONSTRUCTED CONCEPT MAPS (FORM B)

In this form, the features of a concept map are expanded. These additional features reflect a more complete view of concept maps that students develop. They should be used only after the students have had enough exposure to the strategy, and feel confident to expand the strategy.

Ignore all parts of the map for relationships criterion if no relationships are explicitly identified by proper labeling of the connecting line.

RELATIONSHIPS: One point is given for each relationship between two concepts provided the relationship is content correct and explicitly stated. No additional credit is awarded for duplication of the same relationship on the concept map.

HIERARCHY: Points are awarded depending on the degree of hierarchy in the concept map. The number of points given for hierarchy depends upon the number of levels that are identified in the constructed map. Use the map to the right for illustration.



One point is given for at least one correct relationship per level, up until two levels beyond the last branching if the map remains linear.

BRANCHING: The branching of the concept map refers to the level of degree of differentiation among the concepts that are illustrated in the hierarchy. That is, it attempts to rate the degree that specific concepts are connected to more general or inclusive concepts. That rating is as follows:

One point for the first branching where two or more concepts are connected to the concept above.

Three points for any subsequent branching where there is an example of two or more concepts connected to a concept above. The illustrated map above would receive a score of seven; 1 point for Level 1, and three points each for Levels 2 and 3. Note that since no branching occurs in Levels 4 and 5, no further points are awarded for this criterion.

CROSS LINKS: Interrelatedness in a student's concept map indicates an integration of concepts, and is depicted as cross links on the concept map. Cross links show a relationship between concepts on one branch of the hierarchy with concepts on another branch. Notice the two examples of cross links in the illustration above. A rating of one point is given for each cross link showing the integration among concepts. No additional points are awarded for duplication of the same cross link, that is, showing the same integration of concepts.

taken from the work of J.D. Novak

APPENDIX C

DEFINITIONS OF CONCEPTS AND CONCEPT MAPS

DEFINITIONS OF THE WORD "CONCEPT"

DINGLE (1948) - CONCEPTS ARE MANMADE, THEY CHANGE AND ARE FANTASIES.

JAMMER (1957) - CONCEPTS ARE FREE CREATIONS OF THE HUMAN MIND AND ARE NOT, HOWEVER IT MAY SEEM, UNIQUELY DETERMINED BY THE EXTERNAL WORLD.

YORE (1981) - CONCEPTS LEAD TO THEORIES, THEORIES LEAD TO PRINCIPLES, PRINCIPLES LEAD TO LAWS, LAWS LEAD TO PHYSICAL HYPOTHESES, PHYSICAL HYPOTHESES LEAD TO PREDICTED FACTS, PREDICTED FACTS LEAD TO OBSERVATIONS, OBSERVATIONS LEAD TO SCIENCE PROCESS, SCIENCE PROCESS LEADS TO CONSTRUCTS, AND CONSTRUCTS LEAD TO CONCEPTS.

NOVAK (1976) - CONCEPTS ARE A DESCRIPTION OF REGULARITY AMONG FACTS OR OTHER CONCEPTS. FACTS ARE DEFINED AS RECORDS OF EVENTS AND EVENTS ARE THINGS THAT WE OBSERVE HAPPENING OR MAKE HAPPEN. THUS, AN EXPERIMENT PRODUCES EVENTS THAT ARE RECORDED AS FACTS OBSERVED, WHOSE REGULARITY WE TRY TO EXPLAIN WITH RELEVANT CONCEPTS. SOMETIMES WE NEED TO INVENT NEW CONCEPTS TO EXPLAIN THE REGULARITIES WE OBSERVE.

NOVAK (1980) - CONCEPTS ARE DEFINED AS THE REGULARITY IN EVENTS OR OBJECTS DESIGNATED BY A SIGN OR SYMBOL.

THE SCRIBNER-BANTAM ENGLISH DICTIONARY (1979) - CONCEPTS ARE MENTAL IMPRESSIONS OF AN OBJECT.

WEBSTER'S SEVENTH NEW COLLEGIATE DICTIONARY (1963) - CONCEPTS ARE SOMETHING CONCEIVED IN THE MIND; AN ABSTRACT IDEA GENERALIZED FROM PARTICULAR INSTANCES.

TOULMIN (1972) - CONCEPTS, LIKE INDIVIDUALS, HAVE THEIR HISTORIES, AND ARE JUST AS INCAPABLE OF WITHSTANDING THE RAVAGES OF TIME AS ARE INDIVIDUALS.

AUSUBEL (1968) - MEANINGFUL LEARNING OCCURS WHEN NEW INFORMATION IS LINKED TO EXISTING RELEVANT CONCEPTS IN THE LEARNER'S COGNITIVE STRUCTURE.

NOVAK (1976) - CONCEPT LEARNING IS THE MOST IMPORTANT ASPECT IN THE DESIGN OF EFFECTIVE BIOLOGY INSTRUCTION.

STEWART, VAN KIRK, AND ROWELL (1979) - THE CONCEPT MAP IS A DEVICE FOR REPRESENTING THE CONCEPTUAL STRUCTURE OF A DISCIPLINE OR SEGMENT OF A DISCIPLINE, IN TWO DIMENSIONS.